amt-2020-240

Thank you for reviewing the manuscript and providing constructive comments. We have made edits to the manuscript incorporated with your suggestions. Reviewers' comments are shown in black, our response to each comment is shown in blue, and changes to the manuscript are shown in red.

Report #1:
Review of "Comparison of Single Doppler and Multiple Doppler Wind Retrievals in Hurricane Matthew (2016)"
General comments: I thank the authors for their thoughtful replies and careful revisions to their manuscript. The authors have addressed most of my comments adequately. I have comments on Eq. 20 that is newly derived in the revised manuscript.

Specific comments: L202: This is a comment. Eq. 20 describes that the GVTD technique cannot derive the axisymmetric radial wind at R=RT because of the singular point. This is one of the limitations in the GVTD technique, which is not described in Jou et al. (2008).

We have noted the limitations of deriving VRC0 when R = RT in the revised manuscript.

One caveat of the V_RC_0 updated form is that the axisymmetric radial wind cannot be derived when $R = R_T$ because of the singular point.

L356: When the single Doppler analysis is used, is your reply "the retrievals of A2, A3 are variable due to the propagation of wavenumber 2 winds" correct? As shown in Fig. 7b, the GVTD technique using the harmonic 2 and 3 components from the single Doppler analysis can retrieve wavenumber 2 tangential wind reasonably, which is consistent with linear vortex Rossby wave theory. The authors hypothesize in the next paragraph that the discrepancies of retrieved wavenumber 1 and 2 tangential winds are attributed to the dual Doppler wind synthesis. Thus, I think the GVTD technique can also retrieve the axisymmetric radial wind from the single Doppler analysis and it can be validated by using the wavenumber 0 radial wind retrieved by the dual Doppler analysis, which is reliable. However, I do not mean that the authors should do that in this study. I mean, the authors should describe that it is possible but that it is future work. As I wrote in the previous comment, information on the axisymmetric radial wind can be very useful for monitoring and predicting tropical cyclones.
We agree with the reviewer that the axisymmetric radial wind retrieval is valuable for monitoring and predicting tropical cyclones. The retrieval of axisymmetric radial wind could be reasonable when VRC2 and higher order terms are negligible (Eq. C1).

$$\begin{aligned} V_RC_0 = &\frac{A_0 + A_1 + A_2 + A_3 + A_4}{(1 - \frac{R^2}{{R_T}^2})} - \frac{A_0 + A_2 + A_4}{(1 - \frac{R}{R_T})} \\ &- V_RC_2 - \frac{\frac{R}{R_T}}{1 - \frac{R}{R_T}} V_RC_4 - \frac{1}{2}(\frac{1}{1 - \frac{R}{R_T}})(V_TS_5 - V_RC_5) \end{aligned} \tag{C1}$$

However, our analysis shows that the propagation of wavenumber 2 tangential wind is aliased onto the steady wavenumber 1 component, resulting in a reduced amplitude and a phase shift in A_2 and B_2 in the dual Doppler analysis Moreover, [Lee et al., 2006] shows that the Lamb solution of VR2 has comparable magnitude as VT2 but with a phase shift, so the wavenumber 0 radial wind retrieval is uncertain when VRWs are present.

Since the axisymmetric radial wind is influenced by the harmonics 2 and 3, and wavenumber 2 radial wind component (Eq. C1), we cannot fully validate the axisymmetric radial wind retrieval with the current dataset. [Lee et al., 2006] shows that the Lamb solution of the wavenumber 2 radial wind has comparable magnitude as the wavenumber 2 tangential wind but with a phase shift, so the wavenumber 0 radial wind retrieval is uncertain when VRWs are present. The evaluation for the accuracy of the axisymmetric radial wind retrieval is not included in this study.

Report #2:

The authors have done a good job on most of the revisions/responses and the additions are clear. Thank you for this work. However, I still have one major comment that should be addressed. I am recommending major revisions to address this comment. I disagree about the choice of 1 km horizontal grid spacing used in the NOAA P3 retrievals. It doesn't make much sense to use grid spacing below the actual sampling of the radar because the energy will be significantly reduced here anyway. The authors can choose whatever grid spacing they want (even 50-meter spacing), but this doesn't mean anything because these scales are not sampled, and they will be severely damped in the retrievals. The best horizontal grid spacing one can get is limited by the beam sampling interval, which is 1.4 km for the current data. NOAA HRD uses slightly larger grid spacing at 2 km because of this but could probably get away with 1.4 km spacing. The Koch et al. paper is useful, but very old and it only addresses the influence of the weighting factor or influence radius in the data "resolution". New research has shown that the real "resolution" of wind retrieval methods is larger than that quoted by the authors (4dx) and has other contributions from the solution method (3DVAR), additional filtering sometimes used such as Laplacian filtering, post-processing and QC methods. In addition, the authors need to state in the paper the raw sampling of the P3 radials (1.4 km) and the Gaussian filtering applied (4dx), which results in fully resolved fields at 5.6 km, which is really the best it can get. Currently, none of this is mentioned in the paper.

We have now added more clarification to the manuscript on our chosen analysis parameters based on the reviewers comment. One difference between SAMURAI and other analysis software is that 'grid-spacing' is not really an accurate term in this context since the software uses a finite element approach. SAMURAI employs cubic B-splines as a set of basis functions on the 'nodes' which can be used to represent any arbitrary function. The nodal spacing determines the minimum feature size resolved by the function, which is determined by sampling theory. We then apply the low-pass filter as part of the cost-function minimization, with the amount of filtering is specified by the user. In our study, the Gaussian recursive filter length was set to 4Δ the nodal spacing in the horizontal and 2Δ filter in the vertical. We set the nodal spacing (Δ) to 1 km in the horizontal and 0.5 km in the vertical, which results in a 3D wind-field 'function' that can depict features with wavelengths larger than 4 km in the horizontal and 1 km in the vertical. We have chosen a 1-km nodal spacing with a 4Δ filter, but could get a similar functional representation with a 0.5-km spacing and 8Δ filter, or 2-km nodal spacing with a 2Δ filter. As the reviewer correctly points out, the primary limitation for what features are actually resolved in the analysis depends on the data spacing. We have found through analytic testing that the features too close to the 2Δ nodal scale may not be well-represented even with perfect data sampling. It is better to have a slightly finer nodal spacing with a little more filtering than nodal spacing that matches the data spacing exactly. With the along-track spacing $\sim$ 1.4 km, the best possible resolution of derived fields with any technique is 2.8 km, and is more accurately closer to 4 - 6 km depending on noise and details of the specific features and sampling. As such, we believe the minimum horizontal resolved spatial scale of our wind analysis at 4 km is sufficient, so that physical features larger than this scale can be well-represented by the spline function. We have added more of these details to the text to address the reviewer's concerns, as well as references to Ooyama (1987) and Ooyama (2002) which are relevant to the cubic B-spline representation of atmospheric structure.

The dual-Doppler analysis was synthesized with each of the P3 radial passes at 1-km horizontal spline nodal spacing and 0.5 km vertical nodal spacing using SAMURAI software

(Bell et al. 2012) in LROSE, with a 4Δx Gaussian filter in the horizontal and 2Δx filter in the vertical applied. SAMURAI is a three-dimensional variational data assimilation tool that uses a finite element basis to estimate the most likely state of the atmosphere given a set of observations. The nodal spacing of the finite elements should be smaller than the data spacing in order to accurately represent a spline function that can depict the spatial scales resolved by a given data sampling (e.g. Koch et al. 1983, Ooyama 1987, Ooyama 2002) . For the P-3 TDR in 2016, the data spacing is limited in the along-track direction to $\sim$ 1.4 km due to the rotation rate of the radar. With the chosen spline nodal spacing and Gaussian filter length the minimum resolved scale is $\sim$4 km in the horizontal, or approximately 2.85 times the along-track data spacing. Larger-scale features such as low azimuthal wavenumber structures are well-resolved by the analysis.

References

[Koch et al., 1983] Koch, S. E., desJardins, M., and Kocin, P. J. (1983). An interactive Barnes objective map analysis scheme for use with satellite and conventional data. *J. Appl. Meteor. Climatol.*, 22(9):1487 – 1503.

[Lee et al., 2006] Lee, W.-C., Harasti, P. R., Bell, M. M., Jou, B. J.-D., and Chang, M.-H. (2006). Doppler velocity signatures of idealized elliptical vortices. *TAO: Terrestrial, Atmospheric and Oceanic Sciences*, 17(2):429.

[Ooyama, 1987] Ooyama, K. V. (1987). Scale-controlled objective analysis. *Mon. Wea. Rev.*, 115(10):2479 – 2506.

[Ooyama, 2002] Ooyama, K. V. (2002). The cubic-spline transform method: Basic definitions and tests in a 1d single domain. *Mon. Wea. Rev.*, 130(10):2392 – 2415.